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MANUFACTURING METHODS AND TECHNOLOGY FOR PIEZOELECTRIC TRANSFOR--ETC(U)
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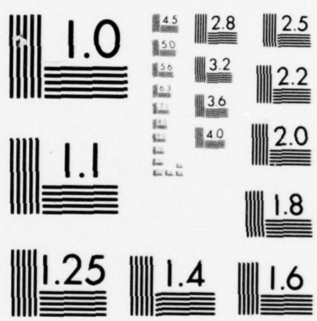


MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

SEVENTH, EIGHTH, NINTH AND TENTH

QUARTERLY PROGRESS REPORTS

PRODUCTION ENGINEERING MEASURE (PEM)



# MANUFACTURING METHODS AND TECHNOLOGY FOR PIEZOELECTRIC TRANSFORMERS

CONTRACT DAAB07-76-C-0008

January 14, 1977 to January 14, 1978

PLACED BY:
TECHNICAL SUPPORT
ACTIVITY, USAERADCOM
FORT MONMOUTH, NEW JERSEY



CONTRACTOR
HONEYWELL INC.
DEFENSE ELECTRONICS DIVISION
CERAMICS CENTER
GOLDEN VALLEY, MINNESOTA



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(9) Quarterly progress rept. nos. 7-10, 14 Jan 77-14 Jan 78

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Image intensifier tubes

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This combined Seventh, Eighth, Ninth and Tenth Quarterly report for Contract DAAB07-76-C-0008 describes the progress and status of this program to establish a cost-effective production capability for piezoelectric, ceramic transformers. The problems encountered in the confirmatory build portion of the program are described. After considerable effort on the many problems associated with the 25mm PET's, it was concluded that the costs associated with the construction of these units would not justify their substitution for the

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20. ABSTRACT -- (Continued)

presently used wire-wound, step-up transformers. The work which has been implemented to correct the minor problems associated with the 18mm PET's is given with the current status of the testing of the confirmatory build samples.

SEVENTH THROUGH TENTH
QUARTERLY REPORT

CONTRACT NO. DAAB07-76-C-0008
Manufacturing Methods and Technology for Piezoelectric Transformers

PERIOD COVERED: January 14, 1977 to January 14, 1978

PREPARED BY: W. Harrison
L. Hiltner
W. Kammeyer

OBJECT OF STUDY:

The objective of this contract is to establish a production capability for piezoelectric ceramic transformers with all required manufacturing methods, test procedures and production tooling for high production rates. These transformers are to be used in conjunction with a power supply for operating night vision image intensifier tubes.

The original objective to demonstrate this capability for both 18mm and 25mm PET's was altered during this period and is now limited to the 18mm PET.

# PURPOSE

This Production Engineering Measure (PEM) contract covers all of the tooling, test methods, package designs, mounting techniques, interconnection techniques and other manufacturing methods and techniques required for eventual production of 18mm piezoelectric transformers. These units are to be used with a power supply to improve the performance and reduce cost for image intensifier tubes used in various 18mm night vision devices.

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# SECTION I
# APPROACH

Our approach to the design of piezoelectric transformers, its advantages and the analytical method used to determine performance of these transformers, was discussed in the first quarterly report[1]. During the engineering sample-build phase of this program it was shown that both of our 18mm and 25mm PET designs were feasible. However, during the confirmatory-build phase which was completed during this report period, it was concluded that the assembly techniques for the 25mm PET were too unreliable and thus too costly. Work on the 25mm PET has, therefore, ceased while that on the 18mm PET is being continued.

(1) First Quarterly Progress Report, Production Engineering Measures (PEM), Manufacturing Methods and Techniques for Piezoelectric Transformers, Contract Number DAAB07-76-C-0008, July 14, 1975, to October 14, 1975.

## SECTION II
## PROCESS REVIEW

All processing steps used on this program up to this time have been documented previously(1) (2) (3) (4) (5) (6) for both the 18mm and 25mm PET's. One minor change in the direction of pin insertion is expected to be made in the final assembly operations (OP 140-170) for the pilot run. This change will improve the solder reheat and handling damage resistance of the package.

(1) First Quarterly Progress Report, p.1.

(2) Second Quarterly Progress Report, Production Engineering Measure (PEM) Manufacturing Methods and Techniques for Piezoelectric Transformers, Contract Number DAAB07-76-C-0008, October 14, 1975, to January 14, 1976.

(3) Third Quarterly Progress Report, Production Engineering Measure (PEM) Manufacturing Methods and Techniques for Piezoelectric Transformers, Contract Number DAAB07-76-C0008, January 14, 1976, to April 14, 1976.

(4) Fourth Quarterly Progress Report, Production Engineering Measure (PEM) Manufacturing Methods and Techniques for Piezoelectric Transformers, Contract Number DAAB07-76-C-0008, April 14, 1976, to July 14, 1976.

(5) Fifth Quarterly Progress Report, Production Engineering Measure (PEM) Manufacturing Methods and Techniques for Piezoelectric Transformers, Contract Number DAAB07-76-C-0008, July 14, 1976, to October 14, 1976.

(6) Sixth Quarterly Progress Report, Production Engineering Measure (PEM) Manufacturing Methods and Techniques for Piezoelectric Transformers, Contract Number DAAB07-76-C-0008, October 14, 1976 to January 14, 1977.

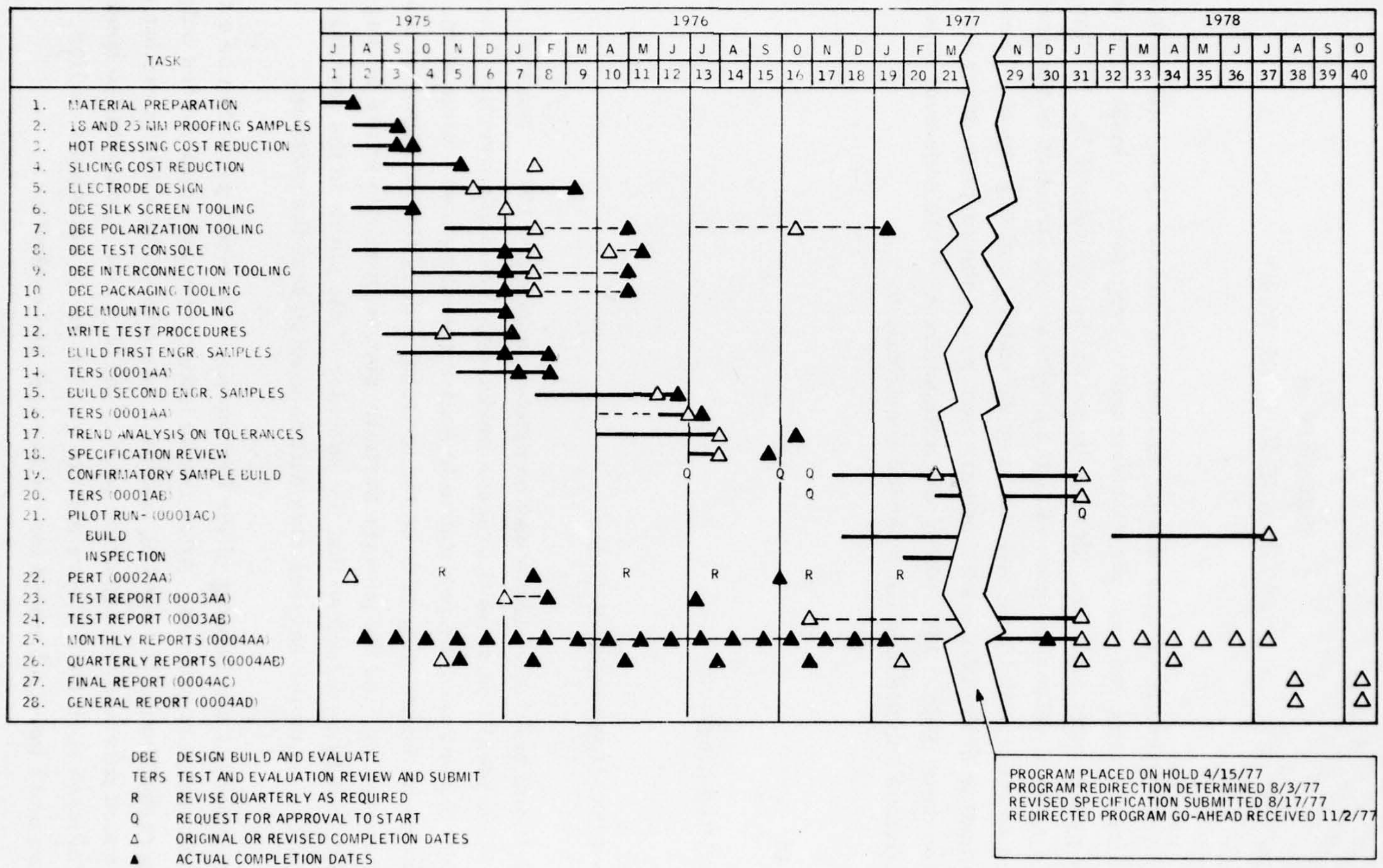


Figure 1. Program Status Against Schedule

## SECTION III
## STATUS AND FUTURE WORK

This section describes the status of work against the various tasks outlined in Figure 1 that were active during the past year's effort on the program. At least eight months during this period were inactive. During the period between April 15, 1977 and November 2, 1977 several extensive reviews of the progress and direction of the program were made based on the initial 18mm and 25mm confirmatory building phase. These resulted in the elimination of the 25mm PET requirement and in the adoption of the Revision IV specification dated August 17, 1977 given in Appendix A. This document supersedes earlier revisions and the original SCS-480 specification.

### TASK 1 - 18

Work completed previously.

### TASK 19 - CONFIRMATORY BUILD

The initial 18mm build of 35 parts was completed in January 1977. However, the initial testing of these identified several process weaknesses needing correction. Several of the packages did not pass the resistance to solder reheating test. Some of the closure pins, soldered to the shorting bars on the terminal side of the package, let loose during the solder reheat test and the package partially popped open. In future packages the closure pins will be reversed so that the shoulder of the pin is on the terminal side and crimping of the pin on the reverse side will be used to seal the package.

The 25mm assembly and bonding of the four ceramic elements proved to be a time consuming and unreliable process. After the 40 initially bonded units yielded only 18 satisfactory uncracked units, the bonding approach was altered back to the earlier process where a bonded pair was used to drive each of the $V_{12}$ and $V_3$ outputs (no bonding between pairs). Fourteen such PET's were built to go with the 18 units built earlier. Thirty of these 25mm units were submitted for further test and evaluation.

During the test and evaluation phase these units suffered extensive damage from the thermal cycling test. There were also many connection problems involving the small ($P_-$) terminal, which did not survive the solder reheat test. Based on the poor performance of the 25mm PET units, it was mutually agreed that further effort on these transformers should be discontinued.

## Table 1. Summary of Confirmatory Sample Tests

| | 18mm PET's | | | | 25mm PET's | |
|---|---|---|---|---|---|---|
| | First Submittal* | | 2nd Submittal** | | 1st Submittal* | |
| | Number Good/ Tested | Percent Good | Number Good/ Tested | Percent Good | Number Good/ Tested | Percent Good |
| Post Thermal Shock | 11/30 | 37 | 31/31 | 100 | 2/30[E] | 7[E] |
| High Temp Storage/Operation | 18/30 | 60 | 3/3*** | 100 | 6/30[E] | 20[E] |
| Low Temp Storage/Operation | 10/30 | 33 | 3/3*** | 100 | 11/30 | 37 |
| | | | | | 23/30[E] | 77[E] |
| Capacitance (Primary) | 29/30 | 97 | 13/13 | 100 | 2/18 | 11 |
| Capacitance (Secondary) | 30/30 | 100 | 13/13 | 100 | 8/18 | 44 |
| Terminal Strength | 30/30 | 100 | 13/13 | 100 | 18/18 | 100 |
| Solder Heat | 15/20 | 75 | 3/3*** | 100 | 21/21 | 100 |
| Post Solder Heat | 11/20 | 55 | 3/3 | 100 | 2/21[E] | 10[E] |
| Induced Voltage | 20/20 | 100 | 13/13 | 100 | 14/20 | 70 |
| Solderability | 3/3 | 100 | 3/3 | 100 | 30/30 | 100 |
| Post Barometric Pressure | 3/3 | 100 | NR | NR | 3/3 | 100 |
| Post Humidity | 0/3 | 0 | NR | NR | 0/3 | 0 |
| Induced Voltage | 3/3 | 100 | 3/3 | 100 | 3/3 | 100 |
| Visual External/Internal | | | 3/3 | 100 | 3 | |
| Life (during) | 3/9 | 33 | 9/9 | 100 | 0/9 | 0 |
| Post Life | 4/9 | 44 | 9/9 | 100 | 0/9 | 0 |
| Mechanical Vibration | 2/7 | 29 | 7/7 | 100 | 2/7[E] | 29[E] |
| Mechanical Shock | 3/7 | 43 | 7/7 | 100 | 1/7[E] | 14[E] |
| Induced Voltage | 7/7 | 100 | 7/7 | 100 | 3/3 | 100 |

* Revision II of specification

** Revision IV of specification

*** Group II Test

NR Not Required

E Based on voltage step-up only. Percent Efficiency less than 50 percent at room temperature or less than 20 percent at low temperature.

The 18mm units built in December 1976 and January 1977 and evaluated during the period from January through March were rejected by our Honeywell Inspection group. After approval to complete the confirmatory build against Revision IV of the specification, the rejected lot was examined and tested at room temperature. Twenty-one of the units indicated in Table 3 performed better than the minimum required efficiency and step-up voltage ratio. Sixteen were faulty. Faulty units were disassembled, cleaned and repaired by resoldering leads to the ceramic, terminals, etc. to produce about 20 repaired packaged 18mm PET's. Eight of these contained new, freshly polarized ceramic elements where four were from a new lot of K-9 material (Batch 2592) and four were from an old lot of K-9 material (Batch 1572). These 41 units were again evaluated and 30 were selected for confirmatory sample submission.

## TASK 20 - TEST CONFIRMATORY SAMPLES

The first submittal of 18mm and 25mm and second submittal of 18mm PET confirmatory samples were evaluated. The results are summarized in Table 1 and discussed below.

### FIRST SUBMITTAL 18mm PET's

The detailed results on the first submittal 18mm PET's are presented in Table 2. After completion of the complete test sequence, only twelve of the thirty 18mm units met all specifications. Nine other units met efficiency and $V_{12}$ voltage step-up, but the $V_3$ step-up voltage was low--between 130 and 145. Nine units completely failed because (1) the resistance to solder heat test melted solder around the closure pins and the package popped open, which broke lead wires and ceramic or caused open circuits; (2) the packages were flexed too far when inserted or removed from the test fixtures; or (3) they were accidentally overheated during the solder reheat test.

Specific test parameters which presented a problem were the post humidity, solder heat and heat shock. All units failed the post humidity test because the PET packages are not sealed until they are encapsulated with other power supply components. It was therefore determined that the humidity test should not be imposed on these units. While no problem was encountered with the barometric pressure test, it was also determined that the test was more appropriate to the encapsulated PET's. Therefore, the barometric pressure test was also eliminated from the test sequence.

About half of the twenty-eight 18mm units which met critical requirements before thermal shock passed the thermal shock test, but the other half were low in voltage step-up until a later time. They then returned to normal operation. One unit which was satisfactory prior to heat shock did not recover because a leadwire to the $V_{12}$ output was broken.

Seven units had at least one functional voltage output but did not meet both output requirements after thermal shock. Two of these units did improve with age sufficiently to be within specification later in the test sequence. Thus, it is apparent that aging of the ceramic element improves the performance of the PET and decreases the impact of thermal shock. Note, for instance, that most of the lower numbered units which were built earlier passed the thermal shock test.

## SECOND SUBMITTAL 18mm PET CONFIRMATORY SAMPLES

The reworked second submittal group of 18mm PET's were evaluated during the period from December 28, 1977 to the present. These tests are complete and detailed data on these parts are given in Table 3 for all tests except the final 500 hour life test units. The 30 units evaluated have met all specification requirements. Included in this group are six units which were recently polarized and three of the six were made from a more recent lot of K-9 PZ-PT. Note that all average data for resonant frequency and voltage step-up are well centered in the specified limits and that efficiency is significantly above the minimum value of 30 percent at room temperature and 15 percent at -54°C.

Based on the data obtained we will request approval of these and permission to start the pilot run of 150 18mm units on February 20, 1978.

## FIRST SUBMITTAL 25mm PET's

As shown in Table 1, most tests of the first submittal 18mm PET's that were 100 percent acceptable were also 100 percent acceptable with the thirty 25mm PET's that were evaluated. For instance, terminal strength, solderability, induced voltage and resistance to barometric pressure were not a problem with either unit. However, primary and secondary capacitance and other electrical properties were significantly out of specification. All units failed the ambient 50 percent efficiency requirement. As shown in Table 4 the 25mm PET's were in the 35 to 45 percent range. However, at -45°C, eleven 25mm PET's met the 20 percent specification requirement and the voltage step-up ratio. In fact, at low temperature, 23 units met the voltage step-up with efficiencies of 15 to 23 percent.

Most of the electrical problems appear to be related to the thermal shock tests. Only 2 of the 30 units met the 165 voltage step-up ratio requirement after thermal shock. It is speculated that units are cracked or leads broken by the high thermal stresses associated between the epoxy bonded ceramic elements. The fragile nature of this approach is also born out by the fracture of the units in the mechanical shock tests. The fact that one unit, S/N 34, passed both mechanical vibration and shock does indicate that the approach can be made to work. However, the reliability of the bonding approach makes the process for the 25mm PET's too costly to be considered further.

## Table 2. First Submittal - 18mm Confirmatory Samples
### A. Group I Test

| | S/N | Resonant Frequency | Efficiency (Percent) | Step-Up $V_{12}$ | Step-Up $V_3$ | Capacitance | | | Dissipation (Percent) | | | Terminal Strength | Induced Voltage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Input (nf) | $V_{12}$ (pf) | $V_3$ (pf) | Input | $V_{12}$ | $V_3$ | | |
| Post Thermal Shock | 33 | 31.668 | 40.2 | 97.45 | 150.71 | | | | | | | OK | OK |
| | 34 | 32.135 | 43.1 | 98.02 | 143.9* | | | | | | | OK | OK |
| | 37 | 31.914 | 48.8 | 112.75 | 166.01 | | | | | | | OK | OK |
| | 54 | 31.913 | 37.2* | 95.18 | 140.51 | | | | | | | OK | OK |
| | 56 | 31.676 | 37.5* | 86.69* | 125.21* | | | | | | | OK | OK |
| | 59 | 32.070 | 41.7 | 99.72 | 141.64* | | | | | | | OK | OK |
| | 63 | 31.873 | 35.6* | 90.65 | 137.68* | | | | | | | OK | OK |
| | 64 | 31.464 | 33.8* | 82.15* | 122.95* | | | | | | | OK | OK |
| | 67 | 32.005 | 42.5 | 103.68 | 155.24 | | | | | | | OK | OK |
| | 68 | 31.558 | 36.4* | 87.82 | 130.31* | | | | | | | OK | OK |
| | 79 | 31.889 | 41.6 | 100.85 | 153.54 | | | | | | | OK | OK |
| | $\bar{X}$ | 31.833 | 39.8 | 95.91 | 142.52 | | | | | | | OK | OK |

Yield 4/11, 2 others OK except $V_3$ Voltage Step-Up Ratio 130-145

* Failures

## Table 2. First Submittal - 18mm Confirmatory Samples (Continued)
### B. Group II Test

| | S/N | Resonant Frequency | Efficiency (Percent) | Step-Up $V_{12}$ | Step-Up $V_3$ | Capacitance | | | Dissipation (Percent) | | | Solder-ability | Induced Voltage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Input (nf) | $V_{12}$ (pf) | $V_3$ (pf) | Input | $V_{12}$ | $V_3$ | | |
| Post Thermal Shock | 30 | 31.736 | 39.2 | 93.48 | 137.11* | | | | | | | | |
| | 36 | 31.841 | 39.7 | 91.78 | 134.28* | | | | | | | | |
| | 57 | 31.843 | 35.80 | 80.45 | 116.15* | | | | | | | | |
| | $\bar{X}$ | 31.807 | 38.23 | 88.57 | 129.18 | | | | | | | | |
| High Temp Storage | 30 | 32.193 | 51.4 | 110.8 | 164.8 | | | | | | | | |
| | 36 | 32.308 | 42.1 | 89.8 | 131.80* | | | | | | | | |
| | 57 | 32.439 | 51.70 | 102.30 | 146.60 | | | | | | | | |
| | $\bar{X}$ | 32.313 | 48.4 | 100.97 | 147.73 | | | | | | | | |
| Low Temp Storage | 30 | 31.064 | 30.0 | 64.02 | 85.0 | | | | | | | OK | |
| | 36 | 31.160 | 31.10 | 62.32 | 82.72 | | | | | | | OK | |
| | 57 | 31.273 | 29.40 | 59.49 | 79.32 | | | | | | | OK | |
| | $\bar{X}$ | 31.166 | 30.17 | 61.94 | 82.35 | | | | | | | OK | |
| Post Resistance To Solder | 30 | 32.073 | 50.3 | 102.0 | 147.3 | | | | | | | | OK |
| | 36 | 32.273 | 48.40 | 91.80 | 133.10* | | | | | | ① | | OK |
| | 57 | 32.261 | 50.80 | 96.30 | 138.80* | | | | | | ① | | OK |
| | $\bar{X}$ | 32.202 | 49.83 | 96.7 | 139.73 | | | | | | | | OK |

① Case opened from solder heat.

Yield = 1/3, 2 others OK except $V_3$ Voltage Step-Up Ratio 130-145

* Failures

## Table 2. First Submittal - 18mm Confirmatory Samples (Continued)
### C. Group III Test

| | S/N | Resonant Frequency | Efficiency (Percent) | Step-Up $V_{12}$ | Step-Up $V_3$ | Capacitance Input (nf) | Capacitance $V_{12}$ (pf) | Capacitance $V_3$ (pf) | Dissipation (Percent) Input | Dissipation (Percent) $V_{12}$ | Dissipation (Percent) $V_3$ | Visual Internal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Post Thermal Shock | 40 | 31.781 | 42.0 | 98.02 | 141.08* | | | | | | | |
| | 43 | 32.020 | 44.5 | 99.72 | 150.71 | | | | | | | |
| | 44 | 31.762 | 39.6 | 87.82 | 129.70* | | | | | | | |
| | 49 | 31.937 | 39.33 | 91.22 | 135.9* | | | | | | | |
| | 50 | 32.013 | 43.50 | 104.25 | 156.37 | | | | | | | |
| | 55 | 32.047 | 43.7 | 104.25 | 146.74 | | | | | | | |
| | 58 | 31.857 | 39.0 | 88.39 | 131.44* | | | | | | | |
| | 61 | 32.036 | 43.3 | 104.82 | 152.97 | | | | | | | |
| | 74 | 32.186 | 50.4 | 64.03* | 95.75* | | | | | | | |
| | $\bar{X}$ | 31.960 | 42.81 | 93.61 | 137.85 | | | | | | | |
| Life Test 2000 Hours | 40 | 32.126 | 48.4 | 96.3 | 135.90* | | | | | | | |
| | 43 | 32.433 | 52.80 | 100.3 | 152.9 | | | | | | | |
| | 44 | 32.099 | 48.80 | 93.50 | 137.7* | | | | | | | |
| | 49 | 32.343 | 47.3 | 90.70 | 133.1* | | | | | | | |
| | 50 | 32.386 | 50.2 | 104.8 | 158.6 | | | | | | | |
| | 55 | 32.618 | 58.8 | 120.1 | 168.8 | | | | | | | |
| | 58 | 35.715 | 12.7* | 45.3* | 212.5* | | | | | | | |
| | 61 | 32.562 | 55.2 | 116.1 | 170.0 | | | | | | | |
| | 74 | 32.680 | 56.3 | 59.5* | 90.7* | | | | | | | OK |
| | $\bar{X}$ | 32.774 | 47.83 | 91.84 | 151.13 | | | | | | | |

Yield = 4/9, 3 others OK except $V_3$ Voltage Step-Up Ratio 130-145

* Failures

## Table 2. First Submittal - 18mm Confirmatory Samples (Concluded)
### D. Group IV Test

| | S/N | Resonant Frequency | Efficiency (Percent) | Step-Up $V_{12}$ | Step-Up $V_3$ | Capacitance Input (nf) | Capacitance $V_{12}$ (pf) | Capacitance $V_3$ (pf) | Dissipation (Percent) Input | Dissipation (Percent) $V_{12}$ | Dissipation (Percent) $V_3$ | Induced Voltage | Visual Internal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Post Thermal Shock | 31 | 32.106 | 39.5 | 92.35 | 146.20 | | | | | | | | |
| | 38 | 32.179 | 49.7 | 118.41 | 175.65 | | | | | | | | |
| | 45 | 32.114 | 42.60 | 97.450 | 139.94* | | | | | | | | |
| | 46 | 31.722 | 41.40 | 91.22 | 134.84* | | | | | | | | |
| | 48 | 31.898 | 45.5 | 101.42 | 147.31 | | | | | | | | |
| | 52 | 31.708 | 39.2 | 95.75 | 135.98* | | | | | | | | |
| | 60 | 31.498 | 31.1* | 81.02* | 118.98* | | | | | | | | |
| | $\bar{X}$ | 31.889 | 41.29 | 96.80 | 142.70 | | | | | | | | |
| Post Vibration | 31 | 32.830 | 59.40 | 59.50* | 91.20* | | | | | | | | |
| | 38 | 32.620 | 54.70 | 111.0 | 166.6 | | | | | | | | |
| | 45 | 32.528 | 45.2 | 90.6 | 128.6* | | | | | | | | |
| | 46 | 32.157 | 49.2 | 91.8 | 138.2* | | | | | | | | |
| | 48 | 32.263 | 49.6 | 97.4 | 140.5* | | | | | | | | |
| | 52 | 32.271 | 55.4 | 115.0 | 161.5 | | | | | | | | |
| | 60 | 32.003 | 47.0 | 95.7 | 142.2* | | | | | | | | |
| | $\bar{X}$ | 32.282 | 51.5 | 94.43 | 138.4 | | | | | | | | |
| Post Mechanical Shock | 31 | 32.791 | 58.1 | 57.80* | 87.80* | | | | | | | OK | |
| | 38 | 32.622 | 59.0 | 118.4 | 176.20 | | | | | | | OK | |
| | 45 | 32.560 | 47.0 | 95.2 | 134.8* | | | | | | | OK | |
| | 46 | 32.190 | 47.4 | 88.9 | 135.4* | | | | | | | OK | OK |
| | 48 | 32.679 | 49.0 | 24.4* | 237.4* | | | | | | | OK | OK |
| | 52 | 32.303 | 57.5 | 119.5 | 167.7 | | | | | | | OK | |
| | 60 | 32.083 | 49.5 | 100.3 | 146.2 | | | | | | | OK | |
| | $\bar{X}$ | 32.461 | 52.5 | 86.36 | 155.07 | | | | | | | OK | OK |

Yield = 3/7, 2 others OK except $V_3$ Voltage Step-Up Ratio 130-145

* Failures

Table 3. Second Submittal - 18mm Confirmatory Samples
A. Group I Test

| | S/N | Resonant Frequency | Efficiency (Percent) | Step-Up $V_{12}$ | Step-Up $V_3$ | Capacitance Input (nf) | Capacitance $V_{12}$ (pf) | Capacitance $V_3$ (pf) | Dissipation (Percent) Input | Dissipation (Percent) $V_{12}$ | Dissipation (Percent) $V_3$ | Terminal Strength | Induced Voltage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Post Thermal Shock | 30[1] | 32.125 | 46.6 | 108.0 | 161.6 | 13.655 | 6.0 | 6.0 | 0.85 | -- | -- | OK | OK |
| | 32 | 32.186 | 42.2 | 94.4 | 143.2 | 13.288 | 6.0 | 6.0 | 0.75 | -- | -- | OK | OK |
| | 33[1] | 32.050 | 43.5 | 102.4 | 166.0 | 13.904 | 5.8 | 5.1 | 0.79 | -- | -- | OK | OK |
| | 34[1] | 32.532 | 45.0 | 102.8 | 156.4 | 12.964 | 6.8 | 5.8 | 0.53 | -- | -- | OK | OK |
| | 37 | 32.306 | 54.0 | 122.8 | 188.8 | 13.853 | 5.7 | 5.5 | 0.49 | -- | -- | OK | OK |
| | 41 | 32.455 | 43.6 | 104.8 | 165.2 | 12.827 | 5.4 | 5.7 | 0.64 | -- | -- | OK | OK |
| | 46 | 32.092 | 40.5 | 86.4 | 136.4 | 13.113 | 6.8 | 6.0 | 0.87 | -- | -- | OK | OK |
| | 52[1] | 32.308 | 50.0 | 116.8 | 171.6 | 14.184 | 5.9 | 5.9 | 0.82 | -- | -- | OK | OK |
| | 61[1] | 32.706 | 53.6 | 126.4 | 192.4 | 13.426 | 5.7 | 6.0 | 0.43 | -- | -- | OK | OK |
| | 65 | 32.279 | 47.4 | 100.8 | 150.8 | 13.186 | 5.1 | 5.1 | 0.65 | -- | -- | OK | OK |
| | 68[1] | 32.093 | 42.1 | 97.6 | 150.8 | 13.652 | 6.5 | 5.9 | 0.92 | -- | -- | OK | OK |
| | 79[1] | 32.312 | 46.8 | 110.4 | 175.2 | 13.522 | 6.8 | 6.0 | 0.58 | -- | -- | OK | OK |
| | 80 | 32.084 | 45.3 | 116.0 | 180.0 | 14.712 | 6.0 | 5.5 | 1.41 | -- | -- | OK | OK |
| | $\overline{X}$ | 32.271 | 46.2 | 106.9 | 164.5 | 13.560 | 6.0 | 5.7 | 0.75 | -- | -- | OK | OK |

Yield = 13/13

(1) First submittal samples resubmitted with no rework.

Table 3. Second Submittal - 18mm Confirmatory Samples (Continued)
B. Group II Test

| | S/N | Resonant Frequency | Efficiency (Percent) | Step-Up $V_{12}$ | Step-Up $V_3$ | Capacitance Input (nf) | Capacitance $V_{12}$ (pf) | Capacitance $V_3$ (pf) | Dissipation (Percent) Input | Dissipation (Percent) $V_{12}$ | Dissipation (Percent) $V_3$ | Solderability | Induced Voltage | Visual External | Visual Internal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Post Thermal Shock | 31 | 32.307 | 38.3 | 90.4 | 148.8 | 13.374 | 6.0 | 6.0 | 0.61 | -- | -- | | | | |
| | 43[1] | 32.593 | 49.6 | 105.2 | 166.4 | 12.735 | 5.5 | 5.1 | 0.70 | -- | -- | | | | |
| | 69 | 31.784 | 40.8 | 96.0 | 145.2 | 14.055 | 6.8 | 6.0 | 1.30 | -- | -- | | | | |
| | $\overline{X}$ | 32.228 | 42.9 | 97.2 | 153.5 | 13.388 | 6.1 | 5.7 | 0.87 | | | | | | |
| High Temp Storage | 31 | 32.507 | 42.6 | 102.8 | 171.2 | | | | | | | | | | |
| | 43[1] | 32.626 | 52.9 | 110.8 | 177.6 | | | | | | | | | | |
| | 69 | 31.870 | 45.0 | 104.4 | 159.6 | | | | | | | | | | |
| | $\overline{X}$ | 32.334 | 46.8 | 106.0 | 169.5 | | | | | | | | | | |
| Low Temp Storage | 31 | 31.168 | 21.1 | 48.0 | 75.3 | | | | | | | OK | | | |
| | 43 | 31.355 | 27.6 | 56.8 | 82.4 | | | | | | | OK | | | |
| | 69 | 30.998 | 26.8 | 59.2 | 84.0 | | | | | | | OK | | | |
| | $\overline{X}$ | 31.174 | 25.2 | 54.7 | 80.6 | | | | | | | OK | | | |
| Post Resistance To Solder | 31 | 32.347 | 36.3 | 86.0 | 137.2 | | | | | | | | OK | OK | OK |
| | 43 | 32.522 | 50.9 | 107.2 | 168.8 | | | | | | | | OK | OK | OK |
| | 69 | 31.889 | 46.9 | 108.8 | 163.2 | | | | | | | | OK | OK | OK |
| | $\overline{X}$ | 32.253 | 44.7 | 100.7 | 156.4 | | | | | | | | OK | OK | OK |

Yield = 3/3

(1) First submittal samples resubmitted with no rework.

Table 3. Second Submittal - 18mm Confirmatory Samples (Continued)
C. Group Group III Test

| | S/N | Resonant Frequency | Efficiency (Percent) | Step-Up $V_{12}$ | Step-Up $V_3$ | Capacitance Input (nf) | Capacitance $V_{12}$ (pf) | Capacitance $V_3$ (pf) | Dissipation (Percent) Input | Dissipation (Percent) $V_{12}$ | Dissipation (Percent) $V_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Post Thermal Shock | 42 | 31.771 | 38.2 | 92.0 | 136.0 | 14.510 | 6.0 | 5.5 | 1.46 | -- | -- |
| | 44(1) | 32.108 | 42.0 | 90.8 | 138.0 | 13.242 | 6.0 | 5.4 | 0.83 | -- | -- |
| | 48 | 32.011 | 42.7 | 100.4 | 160.8 | 14.070 | 6.4 | 5.5 | 1.13 | -- | -- |
| | 49 | 32.277 | 46.0 | 100.8 | 159.2 | 13.022 | 5.7 | 5.0 | 0.78 | -- | -- |
| | 50(1) | 32.424 | 48.1 | 112.0 | 174.8 | 13.445 | 6.4 | 5.6 | 0.62 | -- | -- |
| | 54 | 32.232 | 44.9 | 107.6 | 167.6 | 13.856 | 6.0 | 5.8 | 0.75 | -- | -- |
| | 56(1) | 32.174 | 45.3 | 95.2 | 141.6 | 13.358 | 6.0 | 5.5 | 0.80 | -- | -- |
| | 57(1) | 32.308 | 48.1 | 102.8 | 153.6 | 12.667 | 7.0 | 5.8 | 0.75 | -- | -- |
| | 74 | 32.352 | 38.9 | 91.6 | 144.4 | 13.997 | 5.3 | 5.1 | 0.81 | -- | -- |
| | $\overline{X}$ | 32.184 | 43.8 | 99.2 | 152.8 | 13.574 | 6.1 | 5.5 | 0.88 | -- | -- |
| (96 Hours) | 42 | 31.717 | 49.0 | 89.6 | 132.0 | | | | | | |
| | 44 | 32.076 | 40.0 | 88.0 | 133.6 | | | | | | |
| | 48 | 31.949 | 39.6 | 94.4 | 150.8 | | | | | | |
| | 49 | 32.279 | 45.2 | 100.0 | 156.8 | | | | | | |
| | 50 | 32.390 | 45.7 | 106.0 | 164.0 | | | | | | |
| | 54 | 32.130 | 40.3 | 96.0 | 150.0 | | | | | | |
| | 56 | 31.981 | 40.1 | 84.8 | 130.1 | | | | | | |
| | 57 | 32.272 | 45.4 | 97.6 | 145.6 | | | | | | |
| | 74 | 32.085 | 37.7 | 86.8 | 131.2 | | | | | | |
| | $\overline{X}$ | 32.098 | 42.6 | 93.7 | 143.8 | | | | | | |
| (248 Hours) | 42 | 31.715 | 36.0 | 88.0 | 130.4 | | | | | | |
| | 44 | 32.120 | 40.0 | 90.0 | 136.0 | | | | | | |
| | 48 | 32.033 | 40.3 | 97.2 | 154.8 | | | | | | |
| | 49 | 32.289 | 43.4 | 98.8 | 154.4 | | | | | | |
| | 50 | 32.198 | 42.1 | 97.2 | 150.8 | | | | | | |
| | 54 | 32.265 | 42.4 | 104.4 | 161.2 | | | | | | |
| | 56 | 32.129 | 41.9 | 90.0 | 132.0 | | | | | | |
| | 57 | 32.313 | 44.3 | 98.0 | 145.2 | | | | | | |
| | 74 | 32.204 | 36.7 | 88.0 | 138.0 | | | | | | |
| | $\overline{X}$ | 32.141 | 40.8 | 94.6 | 144.7 | | | | | | |

Yield = 9/9

(1) First submittal samples resubmitted with no rework.

Table 3. Second Submittal - 18mm Confirmatory Samples (Concluded)
D. Group IV Test

| | S/N | Resonant Frequency | Efficiency (Percent) | Step-Up $V_{12}$ | Step-Up $V_3$ | Capacitance | | | Dissipation (Percent) | | | Induced Voltage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Input (nf) | $V_{12}$ (pf) | $V_3$ (pf) | Input | $V_{12}$ | $V_3$ | |
| Post Thermal Shock | 36 | 32.272 | 47.7 | 103.2 | 155.2 | 13.258 | 5.9 | 6.0 | 0.53 | -- | -- | |
| | 45 (1) | 32.511 | 48.7 | 113.6 | 167.6 | 13.751 | 5.8 | 5.9 | 0.52 | -- | -- | |
| | 47 | 32.106 | 46.2 | 100.8 | 149.2 | 13.695 | 5.7 | 5.8 | 0.87 | -- | -- | |
| | 51 | 32.457 | 52.4 | 126.8 | 192.0 | 13.445 | 6.0 | 6.6 | 0.46 | -- | -- | |
| | 55 (1) | 32.755 | 54.0 | 123.6 | 180.4 | 13.391 | 5.3 | 5.7 | 0.40 | -- | -- | |
| | 67 (1) | 32.548 | 51.7 | 123.6 | 191.2 | 13.204 | 6.3 | 5.8 | 0.44 | | | |
| | $\overline{X}$ | 32.441 | 50.1 | 115.3 | 172.6 | 13.457 | 5.8 | 6.0 | 0.54 | | | |
| Post Vibration | 36 | 32.331 | 50.3 | 108.0 | 162.0 | | | | | | | |
| | 45 | 32.551 | 40.4 | 93.0 | 136.0 | | | | | | | |
| | 47 | 32.121 | 46.8 | 101.0 | 148.0 | | | | | | | |
| | 51 | 32.475 | 52.1 | 125.0 | 189.0 | | | | | | | |
| | 55 | 32.777 | 58.9 | 134.0 | 194.0 | | | | | | | |
| | 67 | 32.576 | 53.6 | 127.0 | 195.0 | | | | | | | |
| | $\overline{X}$ | 32.472 | 50.4 | 114.7 | 170.7 | | | | | | | |
| Post Mechanical Shock | 36 | 32.314 | 53.1 | 113.2 | 168.8 | | | | | | | OK |
| | 45 | 32.512 | 55.0 | 126.8 | 186.8 | | | | | | | OK |
| | 47 | 32.134 | 51.3 | 110.4 | 163.2 | | | | | | | OK |
| | 51 | 32.487 | 55.5 | 131.6 | 198.0 | | | | | | | OK |
| | 55 | 32.771 | 57.7 | 133.4 | 196.4 | | | | | | | OK |
| | 67 | 32.615 | 49.8 | 118.0 | 182.4 | | | | | | | OK |
| | $\overline{X}$ | 32.472 | 53.7 | 122.2 | 182.6 | | | | | | | |

Yield = 6/6

(1) First submittal samples resubmitted with no rework.

## Table 4. First Submittal - 25mm Confirmatory Samples
### A. Group I Test

| | S/N | Resonant Frequency | Efficiency (Percent) | Step-Up $V_{12}$ | Step-Up $V_3$ | Capacitance | | | Dissipation (Percent) | | | Terminal Strength | Induced Voltage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Input (nf) | $V_{12}$ (pf) | $V_3$ (pf) | Input | $V_{12}$ | $V_3$ | | |
| Post Thermal Shock | 30 | 29.920 | 37.9* | 134.8* | 135.6* | 37.060 | 13.0 | 12.0 | 0.57 | -- | -- | OK | OK |
| | 32 | 29.704 | 32.6* | 127.2* | 125.6* | 27.050 | 17.5 | 17.0 | 0.65 | 1.0 | 2.0 | OK | OK |
| | 35 | 29.745 | 40.8* | 140.0* | 150.4* | 35.120 | 13.0 | 12.0 | 0.55 | -- | -- | OK | OK |
| | 39 | 29.924 | 40.4* | 135.6* | 134.8* | 38.430 | 15.0 | 14.0 | 0.56 | -- | -- | OK | OK |
| | 40 | 30.218 | 37.0* | 140.4* | 142.8* | 37.850 | 16.7 | 16.1 | 0.69 | 1.0 | 1.0 | OK | OK |
| | 48 | 30.020 | 43.1* | 153.6* | 152.8* | | | | | | | OK | OK |
| | 52 | 29.789 | 39.5* | 154.0* | 160.0* | 38.120 | 14.80 | 15.9 | 0.50 | 1.0 | 2.0 | OK | OK |
| | 55 | 30.072 | 44.7* | 167.2 | 163.2* | | | | | | | OK | OK |
| | 59 | 30.343 | 36.6* | 140.0* | 137.6* | 28.060 | 16.0 | 16.1 | 0.66 | -- | -- | OK | OK |
| | 67 | 30.020 | 22.1* | 111.6* | 111.6* | 28.240 | 15.0 | 14.8 | 0.67 | -- | -- | OK | OK |
| | 71 | 30.120 | 38.6* | 123.6* | 124.4* | | | | | | | OK | OK |
| | $\bar{X}$ | 29.99 | 37.39 | 138.91 | 139.89 | | | | | | | | |

Yield = 0/11

* Failures

## Table 4. First Submittal - 25mm Confirmatory Samples (Continued)
### B. Group II Test

| | S/N | Resonant Frequency | Efficiency (Percent) | Step-Up $V_{12}$ | Step-Up $V_3$ | Capacitance | | | Dissipation (Percent) | | | Solder-ability | Induced Voltage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Input (nf) | $V_{12}$ (pf) | $V_3$ (pf) | Input | $V_{12}$ | $V_3$ | | |
| Post Thermal Shock | 45 | 29.966 | 43.0* | 136.0* | 134.0* | | | | | | | | |
| | 49 | 29.948 | 42.0* | 128.8* | 126.0* | | | | | | | | |
| | 57 | 29.914 | 35.5* | 127.6* | 129.2* | 26.96 | 16.5 | 16.0 | 0.55 | -- | -- | | |
| | $\bar{X}$ | 29.943 | 40.17* | 130.8* | 129.7* | | | | | | | | |
| High Temp Storage | 45 | 30.087 | 35.6* | 163.6* | 122.4* | | | | | | | | |
| | 49 | 30.142 | 38.8* | 132.0* | 129.2* | | | | | | | | |
| | 57 | 30.068 | 24.7* | 114.4* | 115.2* | | | | | | | | |
| | $\bar{X}$ | 30.099 | 33.03* | 136.7* | 122.3* | | | | | | | | |
| Low Temp Storage | 45 | 28.891 | 19.0* | 96.8 | 94.4 | | | | | | | OK | |
| | 49 | 29.000 | 18.0* | 77.6* | 73.6* | | | | | | | OK | |
| | 57 | 29.131 | 20.3 | 78.4* | 77.2* | | | | | | | OK | |
| | $\bar{X}$ | 29.007 | 19.1* | 84.27 | 81.73 | | | | | | | | |
| Post Resistance To Solder | 45 | 29.993 | 43.1* | 142.8* | 144.8* | | | | | | | | OK |
| | 49 | 30.055 | 28.9* | 101.6* | 74.4* | | | | | | | | OK |
| | 57 | 30.160 | 41.4* | 144.8* | 146.8* | 26.10 | 16.2 | 16.0 | 0.44 | -- | -- | | OK |
| | $\bar{X}$ | 30.069 | 37.8* | 129.73* | 122.0* | | | | | | | | |

Yield = 0/3

* Failures

Table 4. First Submittal - 25mm Confirmatory Samples (Continued)
C. Group III Test

| | S/N | Resonant Frequency | Efficiency (Percent) | Step-Up $V_{12}$ | Step-Up $V_3$ | Capacitance | | | Dissipation (Percent) | | | Visual Internal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Input (nf) | $V_{12}$ (pf) | $V_3$ (pf) | Input | $V_{12}$ | $V_3$ | |
| Post Thermal Shock | 36 | 29.567 | 41.5* | 147.2* | 144.8* | 37.60 | 18.9 | 12.8 | 0.50 | -- | -- | |
| | 37 | 29.957 | 39.7* | 133.6* | 134.4 | | | | | | | |
| | 38 | 29.678 | 39.8* | 147.6* | 141.2* | | | | | | | |
| | 41 | 29.716 | 39.6* | 140.0* | 135.6* | | | | | | | |
| | 43 | 30.196 | 41.4* | 140.8* | 136.4* | 38.95 | 3.0 | 3.0 | 1.00 | -- | -- | |
| | 44 | 30.001 | 44.7* | 170.4 | 170.0 | | | | | | | |
| | 50 | 29.910 | 29.4* | 151.6* | 148.8* | | | | | | | |
| | 54 | 30.004 | 40.9* | 138.4* | 134.8* | | | | | | | |
| | 63 | 29.672 | 35.5* | 131.2* | 132.0* | | | | | | | |
| | $\bar{X}$ | 29.856 | 39.17* | 144.53* | 142.0* | | | | | | | |
| After Life Test 2000 Hours | 36 | 30.335 | 30.2* | 161.2* | 54.8* | | | | | | | OK |
| | 37 | 30.169 | 18.9* | 76.8* | 75.2* | | | | | | | |
| | 38 | 29.075 | 14.7* | 87.2* | 82.0* | | | | | | | |
| | 41 | 29.960 | 36.0* | 129.5* | 127.6* | | | | | | | |
| | 43 | 30.238 | 24.4* | 115.2* | 114.0* | 38.40 | 15.7 | 16.0 | 1.56 | 1.0 | 0 | |
| | 44 | 30.063 | 40.0* | 144.0* | 146.8* | 35.63 | 17.0 | 16.6 | 0.55 | -- | -- | |
| | 50 | 29.937 | 25.1* | 139.2* | 139.2* | 38.34 | 17.0 | 17.0 | 1.21 | -- | -- | |
| | 54 | 29.867 | 24.8* | 130.4* | 129.6* | 36.69 | 16.0 | 16.2 | 0.78 | -- | -- | |
| | 63 | 29.882 | 33.8* | 123.2* | 130.0* | | | | | | | |
| | $\bar{X}$ | 29.947 | 27.54* | 122.97 | 111.02 | | | | | | | |

Yield = 0/9

* Failures

Table 4. First Submittal - 25mm Confirmatory Samples (Concluded)
D. Group IV Test

| | S/N | Resonant Frequency | Efficiency (Percent) | Step-Up $V_{12}$ | Step-Up $V_3$ | Capacitance | | | Dissipation (Percent) | | | Induced Voltage | Visual Internal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Input (nf) | $V_{12}$ (pf) | $V_3$ (pf) | Input | $V_{12}$ | $V_3$ | | |
| Post Thermal Shock | 33 | 29.884 | 29.5* | 152.0* | 150.8* | 38.74 | 13.7 | 14.0 | 0.62 | 1.0 | 2.0 | | OK |
| | 34 | 29.681 | 33.9* | 176.4 | 177.6 | 39.60 | 15.0 | 13.80 | 0.59 | -- | -- | | |
| | 47 | 29.751 | 40.3* | 128.4* | 124.8* | | | | | | | | |
| | 53 | 29.699 | 31.6* | 139.2* | 131.6* | | | | | | | | |
| | 56 | 29.943 | 43.2* | 132.8* | 134.0* | 35.61 | 17.9 | 17.3 | 0.66 | 2.0 | 1.0 | | |
| | 61 | 29.610 | 26.8* | 142.0* | 136.0* | 38.24 | 3.0 | 3.0 | 0.60 | -- | -- | | |
| | 66 | 29.977 | 41.3* | 160.0* | 154.8* | | | | | | | | OK |
| | $\bar{X}$ | 29.792 | 35.23* | 147.26* | 144.23* | | | | | | | | |
| Post Mechanical Vibration | 33 | 30.195 | 45.3* | 176.4 | 175.2 | | | | | | | | |
| | 34 | 29.983 | 48.1* | 202.4 | 202.0 | | | | | | | | |
| | 47 | 29.839 | 42.0* | 146.4* | 146.8* | | | | | | | | |
| | 53 | 30.040 | 19.7* | 76.0* | 56.8* | | | | | | | | |
| | 56 | 30.127 | 42.5* | 143.6* | 145.6* | | | | | | | | |
| | 61 | 30.211 | 6.0* | 8.8* | 90.8* | | | | | | | | |
| | 66 | 30.353 | 39.5* | 114.8* | 116.4* | | | | | | | | |
| | $\bar{X}$ | 30.107 | 34.73* | 124.06* | 133.37* | | | | | | | | |
| Post Mechanical Shock | 33 | | No Output* | | | | | | | | | | |
| | 34 | 29.966 | 48.6* | 208.0 | 206.4 | | | | | | | OK | |
| | 47 | 30.100 | 21.3* | 107.6* | 106.4* | | | | | | | OK | |
| | 53 | | No Output* | | | | | | | | | | |
| | 56 | | No Output* | | | | | | | | | | |
| | 61 | | No Output* | | | | | | | | | | |
| | 66 | 29.628 | 14.4* | 57.2* | 56.4* | | | | | | | OK | |
| | $\bar{X}$ | 29.898 | 28.1* | 124.27* | 123.07* | | | | | | | | |

Yield = 1/7 at 45% Efficiency.

* Failures

## SECTION IV
## CONCLUSIONS

The problems encountered in the 18 mm PET confirmatory build portion of this program have been resolved. All confirmatory samples have met their specified requirements in Groups I, II, and IV. The life tests in Group III have also been 100 percent satisfactory up to the midpoint of the test. The last time inverval will be made next quarter. Based on these results a request for starting the pilot production run has been made.

After considerable effort on the 25 mm PET's, it was concluded that the cost associated with the construction of these units would not justify their substitution for the presently used wire wound step-up transformers. The 25 mm PET effort has therefore ceased.

## SECTION V
## RECOMMENDATIONS

Based on the results of the second submittal of confirmatory 18mm samples, it is recommended that approval for constructing the pilot lot of samples be granted. This request will be made by January 20, 1978.

## SECTION VI
## REPORTS

The sixth quarterly report on this program was approved and has been published and distributed during this report period. No other reports or publications have been made on this program.

## SECTION VII
## IDENTIFICATION OF PERSONNEL

During this report period of this program, the following personnel worked the indicated hours in their area of responsibility. No new professional persons, whose backgrounds have not been given previously[(1) (2)], were used.

| INDIVIDUAL | RESPONSIBILITY | HOURS |
|---|---|---|
| W. B. Harrison* | Program Manager | 18 |
| W. H. Kammeyer* | Production Engineer, Ceramic Manufacture and PET Assembly | 22 |
| L. F. Hiltner* | Quality Engineer | 141 |
| M. P. Murphy | Ceramic Technician | 214 |
| | Ceramic Manufacturing | 506 |
| R. Ripley | Insp. PET Testing | 94 |

*Backgrounds given in First and Second Quarterly Reports

(1) First Quarterly Progress Report, p.1.

(2) Second Quarterly Progress Report, p.2.

# APPENDIX A

## HONEYWELL RECOMMENDED SPECIFICATION FOR PIEZOELECTRIC CERAMIC HIGH VOLTAGE TRANSFORMERS

### 1.0 SCOPE

#### 1.1 Scope

This specification covers the requirements for voltage step-up transformers using piezoelectric ceramic materials which are manufactured by hot pressing techniques.

### 2.0 APPLICABLE DOCUMENTS

#### 2.1 Government Documents

The following documents of the issue in effect on the date of invitation for bid or request for proposal, form a part of this specification to the extent specified herein:

Specifications

Military

MIL-T-27 - Transformers and Inductors, General Specification For.

MIL-Q-9858 - Quality Program Requirements.

Standards

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.

MIL-STD-130 - Identification Marking of U.S. Military Property.

MIL-STD-202 - Test Methods for Electronic and Electrical Component.

MIL-STD-456 - Electronic Parts, Date and Source Coding For.

## 3.0 REQUIREMENTS

### 3.1 Item Definition

The piezoelectric ceramic transformer (PET), shall be a solid state electronic device which when driven at its resonant frequency by a regulated oscillator shall provide two separate appropriate A.C. voltage step-up ratios for powering parallel type voltage multipliers for operating image intensifier tubes. The PET shall consist of one element mounted in a plastic case (see Figure 1).

### 3.2 Materials

The PET shall consist of a single ceramic element. A $PbTiO_3$ - $PbZrO_3$ material must be selected to meet the electrical and mechanical requirements specified herein. Other materials selected for mounting and packaging the element into the PET shall be as specified herein and in accordance with MIL-T-27.

### 3.3 Physical Characteristics

The physical characteristics of the PET shall be as specified herein and in accordance with Figure 1. The weight requirement shall be 5 grams maximum (see 4.5.2).

### 3.4 Resistance to Soldering Heat

The PET shall show no evidence of mechanical or electrical damage after immersion in a molten solder pot at 240°C for 5 seconds (see 4.5.6). The PET shall meet the resonant efficiency at resonance (3.8.2) and voltage step-up (3.8.3) after subjection to resistance to soldering heat.

### 3.5 Solderability

The PET shall be solderable (see 4.5.9).

### 3.6 Terminal Strength

The PET shall show no evidence of loosening of the terminals, or other mechanical damage, when a pull of 1/2 pound is applied (see 4.5.7).

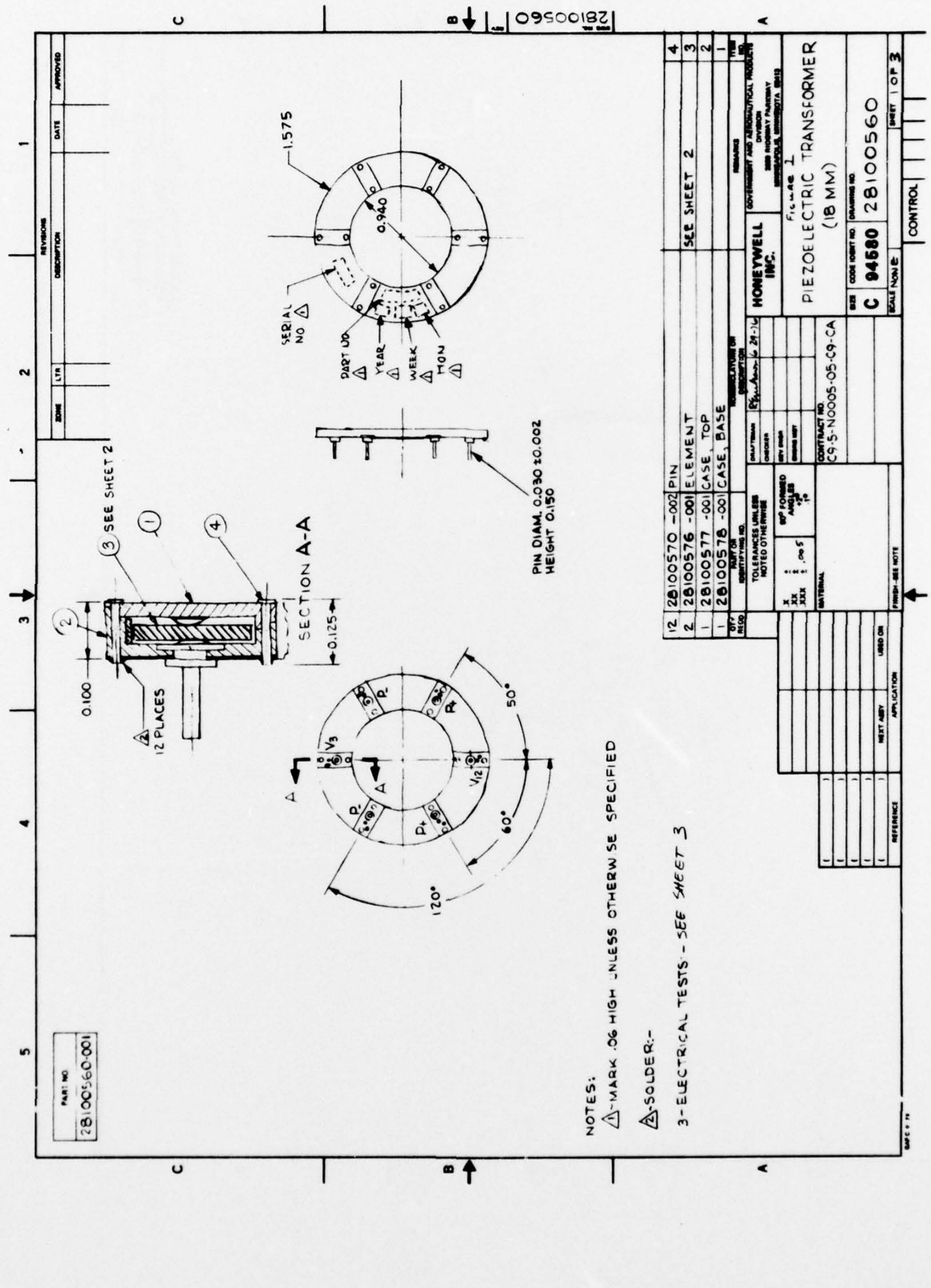


Figure 1. Construction Requirements for the 18mm PET (1 of 3)

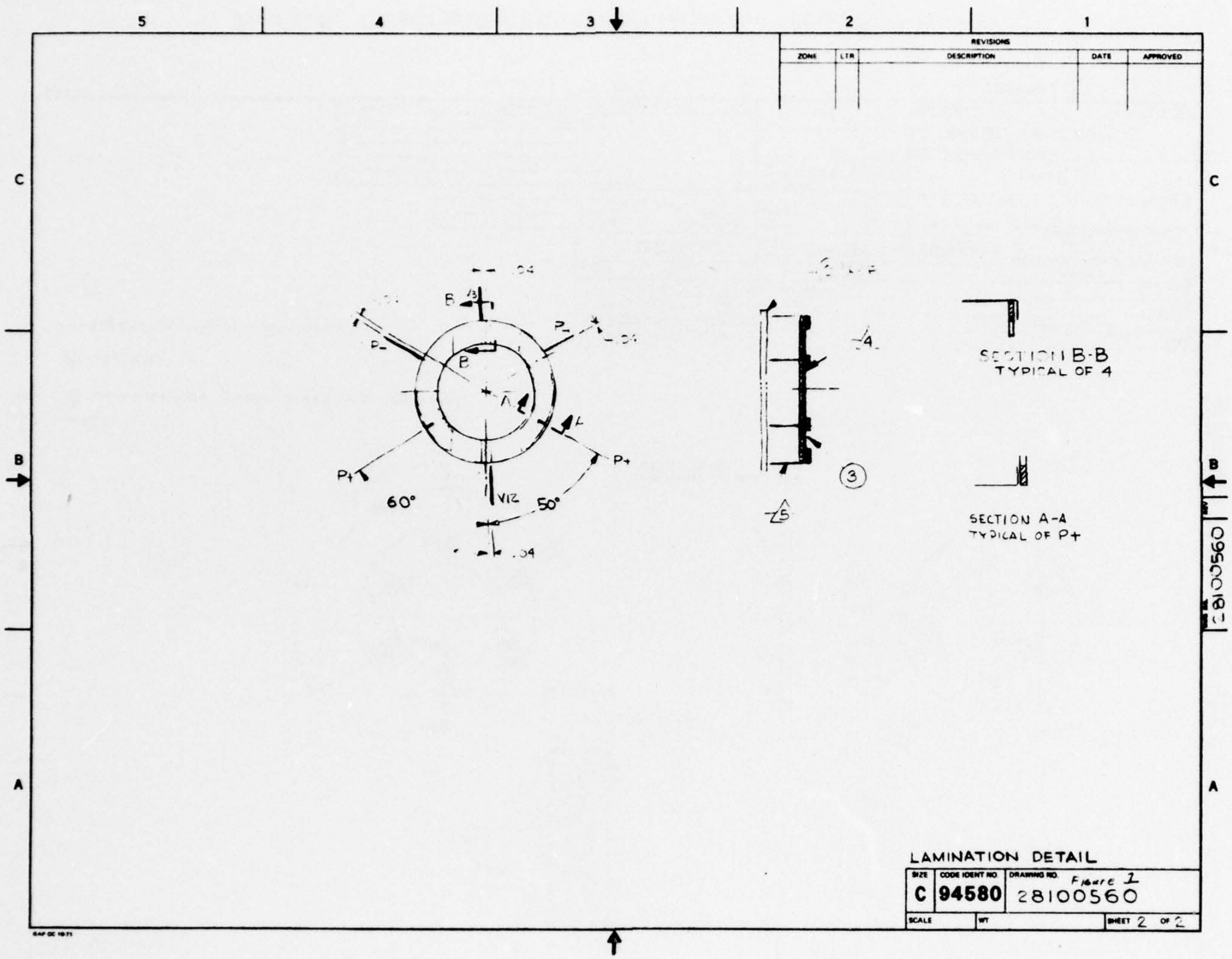


Figure 1. Construction Requirements for the 18mm PET (2 of 3)

## ELECTRICAL REQUIREMENTS

When a 5 volt (p-p) sine wave input voltage to the PET is applied in parallel to the primary terminals ($P_+$ and $P_-$) and the ceramic is driven at its primary resonant frequency with the electrical load on the $V_{12}$ secondary terminal of 2 megohms and 8 pf, and $V_3$ terminal of 100 megohms and 3 pf, the packaged units shall meet the following electrical requirements.

| | | |
|---|---|---|
| Resonant Frequency: | | |
| 22 ± 2°C | 32.3 ± 1.6 kHz | |
| 52 ± 2°C | 32.5 ± 1.6 kHz | |
| -54 ± 2°C | 31.6 ± 1.6 kHz | |
| Stepup Voltage | $V_{12}$ output/input voltage | $V_3$ output/input voltage |
| 22 ± 2°C | 107 ± 27 | 173 ± 43 |
| 52 ± 2°C | 107 ± 27 | 173 ± 43 |
| -54 ± 2°C | 58 ± 14 | 90 ± 18 |
| Percent Efficiency | $\dfrac{\dfrac{V_{12}^2}{R_{12}} + \dfrac{V_3^2}{R_3}}{V_{in} \quad I_{in}}$ | |
| 22 ± 2°C | 30% min. | |
| 52 ± 2°C | 30% min. | |
| -54 ± 2°C | 15% min. | |

Capacitance and Dissipation Factor: The input and output capacitance shall be measured at a nominal voltage and drive of 1 volt and 1 kHz.

| | | |
|---|---|---|
| Input Capacitance at Room Temperature | | 14 ± 1.4 nf |
| Secondary Capacitance at Room Temperature | $V_{12}$ and $V_3$ | 10 pf max. |
| Input Percent Dissipation at Room Temperature | | 1.5% max. |
| Secondary Percent Dissipation at Room Temperature | $V_{12}$ and $V_3$ | 1.5% max. |

The package PET unit must meet the requirements as described herein for solderability, resistance to solder heat, terminal strength, induced voltage, thermal shock, high and low temperature storage, humidity, mechanical shock and vibration, reduced barometric pressure, life and workmanship.

Electrical Requirements

| Size | Code Ident No. | Drawing No. |
|---|---|---|
| C | 94580 | 28100560 |
| | | Sheet 3 of 3 |

Figure 1. Construction Requirements for the 18mm PET (3 of 3)

3.7 Induced Voltage

The PET shall show no evidence of continuous arcing or breakdown nor shall there be an abrupt change in input current when a voltage is applied to the primary sufficient to cause 150 percent of the rated input voltage; i.e., 7.5 volts (p-p) (see 4.5.8).

3.8 Electrical Performance

The PET shall meet the requirements given in Figure 1.

3.9 Thermal Shock

The PET shall show no evidence of mechanical or electrical damage after subjection to thermal shock (see 4.5.13).

3.10 High Temperature Storage

The PET shall show no evidence of mechanical or electrical damage after subjection to a temperature of 71°C for a minimum of 8 hours (see 4.5.14).

3.11 Low Temperature Storage

The PET shall show no evidence of mechanical or electrical damage after subjection to storage at a temperature of -65°C for a minimum of 2 hours (see 4.5.15).

3.12 Mechanical Shock

There shall be no evidence of mechanical damage after subjection to mechanical shock (see 4.5.12).

3.13 Mechanical Vibration

The assembly with operating voltage applied shall not be damaged or suffer degradation of performance when subjected to simple harmonic motion parallel to and perpendicular to the radial axis over a frequency range of 10 to 55 Hz at a constant 2.5 g's for a period of two minutes in each plane (see 4.5.11).

3.14 Life

The PET voltage step-up at resonant frequency shall not decrease greater than 2 percent nor increase greater than 4.5 percent from the initial measurement during and after subjection to an elevated temperature of 52°C for 500 hours of operation. The PET shall meet the induced voltage (4.5.8), resonant frequency (4.5.3.1), efficiency at resonance (4.5.3.2), input capacitance and dissipation factor (4.5.3.4), and secondary capacitance and dissipation factor (4.5.3.5) after subjection to an elevated temperature of 52°C for 500 hours of operation (see 4.5.10).

3.15 Identification and Marking

The PET shall be marked in accordance with MIL-STD-130 with the manufacturer's name or code symbol, terminal identification, and date code in accordance with MIL-STD-436. Terminal and part number identification shall be in accordance with Figure 1.

3.16 Workmanship

The PET's shall be processed in such a manner as to be uniform in quality and appearance (see 4.5.2).

4.0 QUALITY ASSURANCE PROVISIONS (TEST PROCEDURES)

4.1 Responsibility for Inspection

Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, which is acceptable to the government. The government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Classification of Inspection

The examination and testing of PET's shall be classified as follows:

a. Confirmatory build inspection (does not include preparation for delivery) (see 4.3).

b. Quality conformance inspection (does not include preparation for delivery) (see 4.4).

4.3 Confirmatory Build Inspection

4.3.1 The PET's shall be tested as specified in Table 1 in the order shown.

4.3.2 No failures shall be permitted.

4.4 Quality Conformance Inspection

4.4.1 Group A Inspection -- Group A inspection shall consist of the examination and tests specified in Table 2, in the sequence as shown.

4.4.1.2 Sampling Plan -- Statistical sampling and inspection shall be in accordance with MIL-STD-105 for general inspection II. The AQL shall be as specified in Table 2. of this specification. Major and minor defects shall be as defined in MIL-STD-105.

4.4.2 Group B Inspection -- Group B inspection shall consist of the tests specified in Table 3 of this specification in the sequence as shown. Group B inspection shall be performed on sample units that have been subjected to and have passed Group A tests unless it is more practical to select a separate sample from the Lot for Group B inspection.

4.4.2.1 Sampling Plan -- The sampling quantities for each type transformer shall be as specified in Table 3. No more than one failure shall be allowed for each respective subgroup.

4.4.2.2 Rejected Lots -- If an inspection lot is rejected, the contractor may rework it to correct the defects, or screen out the defective units, and resubmit the lot for inspection. Resubmitted lots shall be inspected using Group B inspection quantities and tests as shown in Table 3.

4.5 Method of Examination and Test

4.5.1 Inspection Conditions -- Test will be conducted in accordance with the test procedure specified herein. Unless otherwise specified, the following conditions shall apply.

a. Inspections and test shall be performed in accordance with the test conditions specified in the "GENERAL REQUIREMENTS" of MIL-STD-202.

Table 1. Confirmatory Sample Inspection

| | |
|---|---|
| **Group I (all sample units)** | |
| Visual and mechanical examination (external) | |
| Thermal Shock | |
| Resonant frequency | |
| Efficiency at resonance | |
| Voltage step-up at resonance | |
| Input capacitance and dissipation factor | |
| Secondary capacitance and dissipation factor | |
| Terminal strength | |
| Induced voltage | |
| **Group II (three sample units)** | |
| High-temperature storage | |
| Low-temperature storage | |
| Solderability | |
| Resistance to soldering heat | |
| Induced voltage | |
| Visual and mechanical examination (external) | |
| Visual and mechanical examination (internal) | |
| **Group III (nine sample units)** | |
| Life | |
| **Group IV (six sample units)** | |
| Mechanical vibration | |
| Mechanical shock | |
| Induced voltage | |

Table 2. Quality Conformance Group A Inspection

| | AQL Percent Defective | |
|---|---|---|
| | Major | Minor |
| Thermal shock | 0.65 | -- |
| Visual and mechanical examination (external) | 0.65 | -- |
| Induced voltage | 0.65 | -- |
| Resonant frequency | 0.65 | -- |
| Efficiency at resonance | 0.65 | -- |
| Voltage step-up at resonance | 0.65 | -- |
| Input capacitance and dissipation factor | 0.65 | -- |
| Secondary capacitance and dissipation factor | 0.65 | -- |

Table 3. Quality Conformance Group B Inspection

Subgroup 1 (12 sample units)

High-temperature storage
Low-temperature storage

Subgroup 2 (20 sample units)

Mechanical vibration
Mechanical shock
Induced voltage

Subgroup 3 (9 sample units minimum)

Life
Induced voltage
Visual and mechanical examination (external)

Subgroup 4 (5 sample units)

Solderability
Resistance to soldering heat
Terminal strength
Visual and mechanical inspection (internal)

b. Capacitance load to the PET shall be as indicated in Figure 1.

c. Resistive load to the PET shall be as indicated in Figure 1.

d. Test frequency shall be within ± 2 percent of the nominal value.

e. Applied voltage to the primary shall be 5 volts ± 1 percent peak to peak sine wave input.

f. All critical electrical parameters, (step-up voltage and percent efficiency) shall be measured on well aged PET's (minimum of 30 days after assembly). Data taken at shorter intervals may be extrapolated (based on aging curves) to the 30 day values.

4.5.2 Visual and Mechanical Examination --

4.5.2.1 External -- PET's shall be examined to verify that the physical dimensions, weight, and marking (see 3.15) are in accordance with the applicable requirement. The PET's shall be weighed with a balance having an accuracy of 0.2 grams.

4.5.2.2 Internal -- PET's shall be disassembled and examined to verify that the materials, internal lead wires, internal mounting, and workmanship are in accordance with the applicable requirements (see 3.3 and 3.16).

4.5.3 Room Temperature Electrical Performance (See 3.8) --

4.5.3.1 Resonant Frequency -- With rated voltage applied to the primary of the PET, the secondary voltage shall be measured while the supply frequency is varied over the specified frequency range with the primary voltage held constant. All resonant frequencies shall be noted. Measurements shall be performed at the load condition specified in Figure 1.

4.5.3.2 Efficiency at Resonance -- The PET shall be operated at resonance in accordance with 4.5.3.1. At the loads specified in 4.5.3.1 the primary A.C. current and secondary RMS voltage shall be measured. Efficiency at resonance shall be calculated as:

$$\frac{\dfrac{V_{12}^2}{R_{12}} + \dfrac{V_3^2}{R_3}}{V_{in} \quad I_{in}} \times 100$$

4.5.3.3 Voltage Step-Up at Resonance -- The PET shall be operated at resonance in accordance with 4.5.3.1. At the loads specified in 4.5.3.1, the voltage output at the secondary shall be measured. Voltage step-up at resonance of each output shall be calculated as:

$$\frac{V_{12}\ \text{(Secondary)}}{V_{in}\ \text{(Primary)}} \text{ and } \frac{V_{3}\ \text{(Secondary)}}{V_{in}\ \text{(Primary)}}$$

4.5.3.4 Input Capacitance and Dissipation Factor -- The input capacitance and dissipation factor for the PET shall be determined by a capacitance bridge or other suitable means at 1 volt RMS at 1 KHz applied between the 2 parallel primaries and the 2 parallel grounds.

4.5.3.5 Secondary Capacitance and Dissipation Factor -- The capacitance and dissipation factor of each secondary shall be determined by a capacitance bridge or other suitable means at 1 volt RMS at 1 KHz applied between the secondary and ground.

4.5.4 High Temperature Electrical Performance -- The PET shall be maintained for a minimum of 1 hour at a temperature of plus 52°C (see 3.8).

4.5.4.1 Resonant Frequency -- The resonant frequency shall be determined for operation at plus 52°C in accordance with 4.5.3.1.

4.5.4.2 Efficiency at Resonance -- The efficiency at resonance shall be determined for operation at plus 52°C in accordance with 4.5.3.2.

4.5.4.3 Voltage Step-Up at Resonance -- The voltage step-up at resonance shall be determined for operation at plus 52°C in accordance with 4.5.3.3.

4.5.5 Low Temperature Electrical Performance -- The PET shall be maintained for a minimum of 1 hour at a temperature of minus 54°C (see 3.8).

4.5.5.1 Resonant Frequency -- The resonant frequency shall be determined for operation of minus 54°C in accordance with 4.5.3.1.

4.5.5.2 Efficiency at Resonance -- The efficiency at resonance shall be determined for operation at minus 54°C in accordance with 4.5.3.2.

4.5.5.3 Voltage Step-Up at Resonance -- The voltage step-up at resonance shall be determined for operation at minus 54°C in accordance with 4.5.3.3.

4.5.6 Resistance to Soldering Heat -- PET's shall be tested in accordance with method 210A of MIL-STD-202. The following details shall apply (see 3.4).

a. Depth of immersion of terminals in the molten solder - to a point 3/64 inch from the nearest insulating material.

b. Test condition - 240 ± 5°C for 5 ± 1 seconds.

c. Measurements after test - resonant frequency, efficiency at resonance and voltage step-up at resonance shall be tested in accordance with 4.5.3.1, 4.5.3.2 and 4.5.3.3.

4.5.7 Terminal Strength -- PET shall be tested for terminal secureness in accordance with method 211A of MIL-STD-202. The following details and exceptions shall apply:

a. Test condition letter - A.

b. Applied force - terminal secureness shall be tested by gradually applying a force of 1/2 pound to each pin terminal in the direction of the axis of the terminal (see 3.6).

4.5.8 Induced Voltage -- A test voltage sufficient to cause 150 percent of the rated input voltage shall be applied to the primary of the PET's. The test potential shall be applied for 5 ± 1/2 second. The load on the secondary shall be as specified in Figure 1. During the test, PET's shall be examined for evidence of continuous arcing, breakdown, and abrupt changes in input current (see 3.7).

4.5.9 Solderability -- PET's shall be tested in accordance with method 208C of MIL-STD-202. Each of the terminals is to be tested. Terminals shall be immersed to within 3/64 inch from the nearest insulating material (see 3.5).

4.5.10 Life -- PET's shall be tested in accordance with Method 108A of MIL-STD-202. The following details shall apply:

a. Distance of temperature measurements from specimens - two inches.

b. Still air requirement, not applicable.

c. Method of mounting and distance between specimens - mounted to electrical connections; distance between specimens two inches.

d. Test temperature and tolerance, 52°C ± 2°C.

e. Operating conditions - loading equal to 10 pf, 10 megohm and excitation of the primary equal to or greater than 1.25 times rated voltage. The electrical test circuit shall monitor the PET's during test for evidence of arcing, breakdown or abrupt changes in input current.

f. Test condition letter - C.

g. Measurements - Periodic measurements for voltage step-up at resonant frequency shall be made at intervals of 96 and 240 hours. The final measurements shall be made at the end of the 500 hour life period. After completion of life test, PET's shall be tested for induced voltage (4.5.8), resonant frequency (4.5.3.1), efficiency at resonance (4.5.3.2), input capacitance and dissipation factor (4.5.3.4). Samples shall also be examined for evidence of visual and mechanical damage (see 3.14).

4.5.11 Mechanical Vibration -- The operating potential shall not be applied to the assembly during vibration testing. Tolerance on specified frequencies shall be ± 2 Hz and tolerance on specified acceleration fields shall be ± 0.2 g. Mount the assemblies rigidly, singly or in groups. Subject the assembly to simple harmonic motion applied in a plane parallel to the radial axis at a varying frequency of 10 to 55 Hz. Vary the frequency from 10 to 55 Hz and return to 10 Hz in one minute while maintaining a constant 2.5 g's. Repeat this frequency sweep (two times total). At the conclusion of the two frequency sweeps, apply the simple harmonic motion to the PET in a plane perpendicular to the radial axis and repeat the above two frequency sweeps.

After the vibration tests, the PET shall be tested for resonant frequency (4.5.3.1), efficiency at resonance (4.5.3.2) and voltage step-up at resonance (4.5.3.3) (see 3.13).

4.5.12 Mechanical Shock -- The PET shall be rigidly mounted during shock testing. After the shock tests outlined below, the PET shall be tested for resonant frequency (4.5.3.1), efficiency at resonance (4.5.3.2) and voltage step-up at resonance (4.5.3.3).

4.5.12.1 Longitudinal Impulse -- Rigidly mount the PET with its radial axis in a vertical plane and subject the transformer to three pulses of nominal half sine wave shape having a peak amplitude of not less than 310 g's and duration 0.10 ± 0.05 millisecond. Impact oscillations as measured by the monitoring accelerometer shall be less than 30 g's, 12 milliseconds after initial pulse. Reverse the PET so that the pulse is still parallel to the radial axis but in the opposite direction, and subject it to three pulses of nominal half sine wave shape having a peak amplitude of not less than 310 g's and duration of 0.10 ± 0.05 millisecond. Impact oscillations as measured by the monitoring accelerometer shall be less than 30 g's, 12 milliseconds after initial pulse (see 3.12).

4.5.12.2 Transverse Impulse -- Rigidly mount the PET with its radial axis in a horizontal (transverse) plane and subject the assembly to 3 pulses of nominal half sine wave shape whose peak amplitude is 910 ± 45 g's, and whose duration of 0.10 ± 0.05 millisecond. After-oscillations must not exceed 90 g's at 12 milliseconds after initial pulse (see 3.12).

4.5.13 Thermal Shock -- PET's shall be tested by exposing them alternately for 15 minutes minimum to +68°C and to -57°C with a minimum of 1 minute between temperature extremes. This sequence will be repeated 5 times (see 3.9).

4.5.14 High Temperature Storage -- PET's shall be subjected to a minimum storage period of 8 hours at plus 71°C. The ambient temperature shall then be gradually lowered to plus 52°C. Measurements shall then be made of the resonant frequency, efficiency at resonance and voltage step-up ratio in accordance with 4.5.4.1, 4.5.4.2 and 4.5.4.3 (see 3.10).

4.5.15 Low Temperature Storage -- PET's shall be subjected to a minimum storage period of 2 hours at minus 65°C. The ambient temperature shall then be gradually raised to minus 54°C. Measurements shall then be made of the resonant frequency, efficiency at resonance and voltage step-up ratio in accordance with 4.5.5.1, 4.5.5.2 and 4.5.5.3 (see 3.11).